ISCRE25 FLORENCE 2018
BRIDGING SCIENCE & TECHNOLOGY
The 25th International Symposium on Chemical Reaction Engineering
20-23 May 2018
Florence, Italy
www.aidic.it/iscre25

Performance study of Dense-feeding of pulverized coal into an HPHT gasifier.

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Highlights

- Performance of feeding pulverized coal into the HPHT gasifier was evaluated.
- Both particle size and operation pressure can affect the discharge behaviors.
- Pulverized coal can be pneumatic conveyed within 10% mass fluctuation.

1. Introduction

The entrained-flow pulverized coal gasification is undergoing rapid industrialization around the world with the characterization of large-scale, high efficiency and clean emissions.[1] Gasifier, acted as an HPHT reactor designed to operate at the pressure of 4.0 MPa and the temperature of 1400 ℃, is the key equipment of the whole process. Reliable feeding of pulverized coal into the gasifier is an important issue for the dry coal gasification technology since it can affect the final product quality and the efficiency of the processes.[4] Therefore, it is very necessary to feed pulverized coal into this HPHT reactor within the prescribed time and in a controlled way to ensure the continuous and smooth process operation.[2]

This work was carried out in the industrial demonstration plant of pulverized coal gasification technology located in Nanjing, China. We mainly focus on the feeding system of the gasification process. The purpose of this work is to assess on the performance of feeding pulverized coal into the HPHT gasifier.

2. Methods

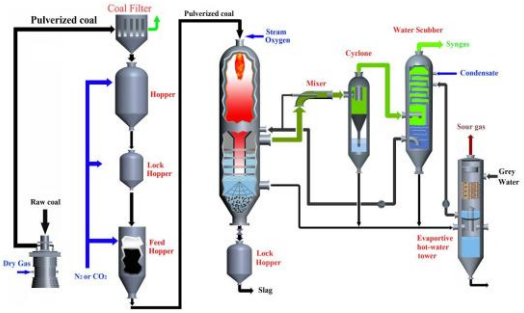

Figure 1. Process schematic diagram of entrained-flow pulverized coal gasification.

The research was carried out in a SE gasification industrial plant located in Yangzi Petrochemical Company Ltd., Nanjing, China. Figure 1 shows the process schematic diagram of entrained-flow pulverized coal gasification. In order to feed pulverized coal into the HPHT gasifier, two units are included: the hopper discharge unit and the pneumatic conveying unit. In the former, locks hoppers are used to feed solids into higher pressure reactor vessels, which receives pulverized coal at atmospheric pressure and, after suitable pressurization, discharges the pulverized coal under gravity into a lower feed hopper. In the latter, the feed hopper operates at almost constant pressure, slightly above that of the gasifier to assist feeding and prevent reverse flow of hot gases and bed materials from the gasifier. The pulverized coal is conveyed from the feed hopper to the HPHT gasifier by dense-phase pneumatic conveying technology.

The experimental data were taken at different operation times and the experimental materials (named coal A and B) were taken at corresponding times from the SE gasification industrial plant. The gasifier is operating

at 60~70% capacity, using CO_2 as carrier gas with respect to its production of hydrogen. The operation conditions were provided in Table 1. Coal A and B cover a certain range of sizes with a mean particle diameter of 14.0μm and 19.8μm, respectively. Both coals are dried to eliminate the effect of moisture content.

Table 1. Typical operation conditions in the SE gasification industrial plant.

Condition / Material	Pressure of feed hopper (MPa)	Pressure of gasifier (MPa)	Coal mass flow rate (t/h)	Solid concentration (kg/m^3)	Solid velocity (m/s)	Valve opening (%)
Coal A	4.26	3.27	14.04	233	6.36	21.0
Coal B	4.20	3.31	12.94	209	6.50	22.3

3. Results and discussion

The flowability determines the powder operation properties with respect to arching in the hopper and jamming during the conveying process in a pipeline. In this work, Carr's flowability index was adopted to characterize the flow properties of pulverized coal, which was defined as the sum of the four items (angle of repose, compressibility, spatula angle and uniformity) measured by the PT-X powder flow tester, produced by Hosokawa Micron Group. The experimental results gave values of Carr's flowability index 55 and 60 for coal A and coal B, respectively. It therefore came to the conclusion that both coals indicated the cohesive characteristics and poor flowability. The flowability of coal A was worse, corresponding to the fact that it had small particle size and contained more fines.

For the discharge unit, coal is discharged from the atmospheric hopper and then from the lock hopper which operated at atmospheric pressure and high pressure, respectively. Because of the large outlet diameter (300 mm) and the half opening angle (15 °), pulverized coal rarely presents discharge problems when flowing out of the atmospheric hopper, which can be always accomplished rapidly with the discharge time arranged from 90 s to 110 s giving the solid discharge rate around 1000t/h. However, after pressurization in the lock hopper, pulverized coal frequently will not discharge reliably and smoothly. The time of pulverized coal discharge from the lock hopper is ranged from 587 s to 886 s. The worst case is the formation of the static arch during the discharge which can block the flow completely.

For the pneumatic conveying unit, two conveying pipelines with inner diameter of 54 mm are led out from the bottom of the feed hopper, from which the pulverized coal is carried by high pressurized CO_2 along a 30-m-long vertical section, a 10-m-long horizontal section, and finally entered the gasifier. The dense-phase pneumatic conveying of pulverized coal in the SE gasification plant is relatively stable, though the pressure signal of the feed hopper shows some periodic features which is worth to minimize to seek for better feeding properties. The pipe pressure maintains at a nearly constant value with small fluctuations. The coal mass flow rate, determined by both the system pressure difference and the valve opening, shows a fluctuation of about 10%. The solid concentrations are 233 kg/m^3 and 209 kg/m^3 for coal A and B, respectively, typical of dense flow.

4. Conclusions

In this paper, dense-feeding of pulverized coal with different particle sizes were investigated in the SE gasification industrial plant. The performance of feeding pulverized coal into the HPHT gasifier as well as its influencing factors were discussed.

References

[1] X. Gong, W. Lu, X. Guo, Z. Dai, Q. Liang, H. Liu, H. Zhang, B. Guo, Fuel, 129 (2014) 37-44.
[2] H. Lu, X. Guo, Y. Jin, X. Gong, Ind. Eng. Chem. Res. 56 (2017) 9734-9742.

Keywords
HPHT gasifier, dense-feeding of pulverized coal, flowability